BULLETIN

OF THE

Society for the

Promotion of Engineering Education

Vol. I LANCASTER, PA., OCTOBER, 1910 No. 3

EDITORIAL.

German Educational Methods.—The last monthly BULLETIN contained Mr. Koester's paper on technical education in Germany which gave the view-point of a German upon this much-discussed subject. In this issue the first section of Dean Shepard's paper upon the same subject, but from a different view-point, is printed. Dean Shepard takes up in this part of his paper the effect of the student's preparation, of the military service, of the practise year, and of other important phases of the German student's training. In the second part of his paper, to be published later, he gives his observations on the German professor and his assistants. There has been in the past a considerable tendency for American students to go abroad for technical training. Whether or not this is necessary or desirable is well worth special study. A phase of the subject that is treated but slightly in the papers mentioned is this: Will an American student derive many of the benefits of the German method if he spends one or two years in Germany? The written discussion of these papers might well bring out opinions upon this point.

Local Organizations.—Among the suggestions made by Mr. Frost at the Madison meeting was one relating to the formation of branches or sections. The Secretary also called attention to this in the June issue of the BULLETIN. It is suggested that the members, located conveniently for the purpose, get together now and then to discuss educational matters brought up by the Society. There are surely enough topics of interest now before us to furnish material for several interesting meetings this winter.

The Bulletin Advertisers.—The possibility of publishing a BULLETIN depends upon the attitude of advertisers toward the project. A number of advertisers have agreed to assist in launching the BULLETIN and to determine by experiment its advertising value. One way in which they can determine the latter is from the number of correspondents who refer to the BULLETIN advertisements. The Publication Committee requests, therefore, that the advertisements be carefully read and when, as a result, correspondence follows, that the BULLETIN be given credit for its work.

Written Discussion.—Attention has been called to the fact that one of the principal purposes of the BULLETIN is to bring out written discussion on the papers. The number of members who hear the papers read is relatively small and the discussion at the meeting is more or less off-hand. With the printed papers in the hands of the entire membership, carefully considered contributions to the discussion should be forthcoming. In the past there has been very little written discussion, because comparatively few of the members saw the papers until they were finally published in the PROCEEDINGS. Now the case is different. During the summer very little discussion has been sent in to be published in the PROCEEDINGS. It must be received by the Secretary before December 1. The members are requested to give this matter special consideration.

Our Growing Membership.—The year has opened up in a very encouraging way regarding growth in membership. In this issue is given a list of those recently elected and others whose applications have been received. A study of these lists shows that the Society appeals to the very best men in the engineering profession. It is an honor to belong to a society with which such men desire to affiliate. The new Membership Committee would like to have 1,000 members in the Society by January 1, 1911. The rate at which applications are now coming in will, if maintained or slightly increased, bring the desired result. If all members were as much interested as a few now are, the Society would grow enormously.

MEMBERSHIP LIST CORRECTIONS.

The following corrections in the membership list have been brought to the attention of the Secretary since the September BULLETIN was printed:

Betts, Philander (Schuer Bldg., Newark, N. J.); Dorsey, J. W. (Lecturer in Electrical and Mechanical Engineering University of Manitoba, Winnipeg, Man.); Hibbard, H. W. (add house address 1307 Kaiser Ave.); Ives, F. W. (care of Department of Engineering Drawing, Ohio State University, Columbus, O.); Ketchum, M. S. (address should be, University of Colorado, Boulder, Colo.); Kottcamp, G. A. (address given as unknown in September BULLETIN is now correct as in April list); Kunze, E. J. (Assistant Professor of Mechanical Engineering, Michigan Agricultural College, East Lansing, Mich.); Noble, H. P. (Falls Church, Fairfax Co., Va.); Nottingham, A. R. (until further notice, Ithaca, N. Y.); Upson, W. L. (University of Vermont, Burlington, Vt.); Williston, A. L. (until further notice, care of W. W. Simmons, 102 Bay St., Manchester, N. H.).

SOCIETY NOTES.

Conservation Congress.—The Second National Conservation Meeting occurred at St. Paul, Minnesota, from September 5 to 9 inclusive. It was a meeting destined to be of lasting importance and President Talbot, therefore, accepted the invitation extended by the managers and appointed a committee of five to represent the Society. The committee comprised Dean W. G. Raymond, Dean F. E. Turneaure, Dean F. C. Shenehon, Dean C. R. Richards and Professor R. H. Slocum. An early and interesting report from this committee is anticipated.

Dr. C. B. Dudley.—Professor Edgar Marburg has in preparation a biographical sketch of the late Dr. Chas B. Dudley, for sixteen years a member of the Society. Professor Marburg states, "I am keenly alive to the limitations of my powers to convey what is felt by all those who were privileged to stand in close personal relationship with that truly rare man." The American Society for Testing Materials will shortly issue a memorial volume in memory of Dr. Dudley.

Inauguration of Dr. McVey.—The Society was officially represented at the inauguration of Dr. Frank LeRond McVey as president of the University of North Dakota, on September 27 to 29, by Professor B. B. Brackett and Dean H. T. Eddy.

Membership Committee.—President Talbot has appointed an informal committee to consider and execute plans for increasing the membership of the Society. The committee has been selected to include different occupations and locations. The composition of the committee is at present as follows: President V. C. Alderson, Professor W. S. Franklin, Professor A. E. Haynes, Professor H. W. Hibbard, Professor D. C. Jackson, Professor H. S. Jacoby, Professor W. T. Magruder, Professor D. A. Murray, Professor A. H. Patterson, Mr. C. F. Scott, Professor F. W. Sperr and Dr. J. A. L. Waddell.

COUNCIL ACTIONS.

The Bulletin.—The matter of publishing a monthly BULLETIN was referred by the Madison meeting to the Council with power. By the Council the Program Committee was directed to report more in detail on the subject than the Executive Committee was able to do at the time of the meeting. As soon as the members of the Program Committee arrived at their homes they formulated a report which indicated the practicability of publishing a monthly BULLETIN and recommended that it be tried for a year. By letter ballot, on motion of the Program Committee the following action was taken.

PUBLICATION OF THE BULLETIN IN 1910–1911.

The publication of the "BULLETIN of the Society for the Promotion of Engineering Education" is authorized for the year 1910–1911. Ten numbers may be issued.

The BULLETIN may contain the proceedings of the annual meeting of the Society, papers and abstracts and discussions of papers, and reports of committees which have been presented at the annual meeting, and advance papers and reports for the next annual meeting. A limited amount of space may be devoted to notes from colleges and other items of general interest. The membership list may be given in one issue. Matter printed in the BULLETIN may or may not be printed in the annual PROCEEDINGS of the Society.

For the year 1910–1911 the Publication Committee shall have charge of the publication of the BULLETIN, subject to the financial control of the Executive Committee.

For the year 1910–1911 no charge will be made in the dues, and the BULLETIN will be sent to all members of the Society without charge. The Program Committee is asked to report to the Council, at the next annual meeting, its views on the continuation of the publication of the BULLETIN, and, if favorable, to formulate plans and regulations for its publication.

New Members.—The Council by letter ballot, September 1, elected the following members:

DE CHATELAIN, M. A., Professor of Electrical Engineering, Polytechnic Institute, Sosnovka, St. Petersburg, Russia..... 1910

FISHER, R. H., Chairman, Division of Forestry, Harvard University, Cambridge, Mass. 1910
KOESTER, FRANK, Consulting Engineer, J. G. White and Co., 400 W. 57th St., New York City..... 1910

APPLICANTS FOR MEMBERSHIP.

The following applications will be acted upon by letter ballot early in October. If other applications are received at once they may be included. The next ballot will be too late for the 1911 year book.

AKELEY, L. E., Dean of the College of Engineering and Professor of Physics, University of South Dakota, Vermillion, S. D..... 1910
BARLOW, W. E., Professor of Metallurgy and Metallography and Dean of Graduate Department, Virginia Polytechnic Institute, Blacksburg, Virginia. 1910
BEAN, P. L., Assistant Professor of Civil Engineering, University of Maine, Orono, Me..... 1910
BENSEL, J. A., President Board Water Supply, New York City, 67th St. and Broadway, New York City..... 1910
BREITHAUPT, W. H., Consulting Civil Engineer, Firm of Keating & Breithaupt, Toronto, Ontario, Canada..... 1910
BUCK, A. M., Professor of Electrical Engineering, Clarkson School of Technology, Potsdam, N. Y..... 1910
BURNS, C. S., Consulting Hydraulic Engineer, Firm of Burns & McDowell, Kansas City, Mo..... 1910
BURT, H. J., Contracting Manager American Bridge Company of New York, Denver, Colo..... 1910
CHURCH, I. P., Professor of Applied Mechanics and Hydraulics, Cornell University, Ithaca, N. Y..... 1910
COLPITTS, W. W., Chief Engineer, Kansas City, Mexico and Orient Railway, Kansas City, Mo..... 1910
COOKE, M. L., Consulting Engineer, 401 W. Walnut Lane, Germantown, Philadelphia..... 1910
DAGGETT, P. H., Associate Professor of Electrical Engineering, Univ. of North Carolina, Chapel Hill, N. C..... 1910
GIBBS, E. A., Engineer of Erection, McClintic-Marshall Construction Co., Gray Apartments, Wilkinsburg, Pa..... 1910
GIBSON, A. J., Lecturer in Engineering Design, Univ. of Sydney, Sydney, N. S. W., Australia..... 1910
GOLDMARK, HENRY, Designing Engineer, Isthmian Canal Commission, Culebra, Canal Zone, Panama..... 1910
HALLSTED, J. C., Engineer, Robert W. Hunt Co., Evanston, Ill.... 1910

HAZELTINE, L. A., Instructor in Electrical Engineering, Stevens Institute of Technology, Hoboken, N. J..... 1910

HENDERER, W. O., President, The Osborn Engineering Co., Cleveland, O. 1910

HOEFER, E. G., Professor of Mechanical Engineering, University of Wyoming, Laramie, Wyo..... 1910

IYER, R. P., Overseer, Public Works Department, Hindupoor P. O., Deccan, India..... 1910

JARRETT, E. S., Secretary and Treasurer, The Foundation Co., 115 Broadway, New York City, N. Y..... 1910

JOHNSON, PHELPS, Vice-President and General Manager, Dominion Bridge Co., Montreal, Canada..... 1910

KAULFUSS, J. E., Instructor in Civil Engineering, University of Maine, Orono, Me..... 1910

KELLEY, H. G., Chief Engineer, Grand Trunk Railway System, Montreal, P. Q., Canada..... 1910

MCCLINTIC, H. H., Vice-President and General Manager, The McClintic-Marshall Construction Co., Pittsburg, Pa..... 1910

MCNAUGHER, D. W., Partner, Robert W. Hunt & Co., Engineers, Allegheny City, Pa..... 1910

METCALF, LEONARD, Consulting Civil Engineer, 14 Beacon St., Boston, Mass. 1910

RALSTON, J. C., Consulting Engineer, also Vice-President and Consulting Engineer, Pacific Coast Pipe Co. of Seattle, 2421 W. Mission Ave., Spokane, Wash. 1910

RASCHE, W. H., Professor of Graphics, Virginia Polytechnic Institute, Blacksburg, Va..... 1910

SAYRE, H. A., Professor of Mathematics, University of Alabama, University, Ala. 1910

SCHUYLER, J. D., Consulting Hydraulic Engineer, 1118 Union Forest Bldg., Los Angeles, Calif..... 1910

SMITH, H. W., Engineer with Westinghouse E. and M. Co., 401 Gray Bldg., Wilkinsburg, Pa..... 1910

STEVENS, J. F., President, Oregon Trunk Railway, Oregon Electric Railway, P. A. C. and Eastern Railway, United Electrical Railway, Portland, Ore..... 1910

STEWART, G. W., Professor of Physics, State University of Iowa, Iowa City, Ia..... 1910

WITTIG, GUSTAV, Professor of Electrical Engineering and Physics, University of Alabama, Tuscaloosa, Ala..... 1910

WOLFEL, P. L., Chief Engineer, McClintic-Marshall Construction Co., Pittsburg, Pa..... 1910

WOODWARD, S. M., Professor of Hydraulic and Engineering Materials, State University of Iowa, Iowa City, Ia..... 1910

COLLEGE NEWS.

California University.—The civil engineering department has had two instructors added this year to the staff through the creation by the Regents of two new positions. Mr. H. S. Griswold, a graduate of Massachusetts Institute of Technology, will assist Professor C. G. Hyde in the Sanitary Engineering courses. Mr. A. J. Eddy, a graduate of the University of California, will assist Professor T. B. Sears and other instructors in surveying and railroad work.

Florida University.—Professor A. J. Wiechardt, M.E. (Lehigh), M.M.E. (Cornell), M.A.S.M.E., formerly professor of mechanical engineering in the Mississippi College of Agriculture and Mechanic Arts, has been appointed professor of mechanical engineering in the University of Florida.

George Washington University.—Professor Philander Betts has been granted an extended leave of absence to permit him to become Chief Inspector of the Utilities Division of the New Jersey Public Utilities Commission.

Kansas University.—Dean Marvin sends out an interesting four-page circular letter to alumni giving, in informal fashion, the news which will interest and encourage them. This is a desirable practice and it encourages the alumni to believe that they are not forgotten when they leave the college halls. The spirit of these letters may be gathered from this closing sentence: "Wishing you the satisfaction of filling your place in life's activities worthily, and ample recognition of your services, I remain as ever, your old friend, Frank O. Marvin."

Michigan Agricultural College.—Dean Bissell reports that from statistics furnished by 196 of the 269 engineering-graduates of Michigan Agricultural College, classes '88 to '07 inclusive, the following table has been prepared.

CLASSIFIED VOCATIONS OF ENGINEERING ALUMNI, MICHIGAN AGRICULTURAL COLLEGE.

Vocations.	Number	Average Salaries.	Number. Reporting Salaries.
Presidents, secretaries, managers, etc...	21	$2,697	12
Executive, technical, consulting, teaching, etc.	64	2,564	57
Superintendents, foremen, chief draftsmen, inspectors, etc.....	68	1,598	60
Assistants, draftsmen, apprentices, clerical, etc.	33	1,239	29
Non-Engineering	10	2,550	8

The following are the average salaries for classes '02 to '07 inclusive.

Class of '07.....	$1,299	32 reporting out of 44
Class of '06.....	1,569	33 reporting out of 42
Class of '05.....	1,635	17 reporting out of 26
Class of '04.....	1,481	16 reporting out of 19
Class of '03.....	1,913	11 reporting out of 26
Class of '02.....	2,250	5 reporting out of 20

North Carolina A. and M. College.—Last year was the best in the history of the college with 590 students registered. Forty-four men graduated in engineering in May; 17, 16, 8 and 3 respectively in electrical, civil and mechanical engineering and chemistry. Slow but steady progress is being made on the new engineering building which will have 36,000 square feet of floor space.

Ohio State University.—Professor F. C. Caldwell, head of the Department of Electrical Engineering, has been granted leave of absence for the coming year, and, together with his family, will spend the winter in the neighborhood of Los Angeles. Associate Professor J. H. Hunt will have charge of the department during his absence. Professor W. L. Upson, for the past two years Assistant Professor in the Department of Electrical Engineering, has accepted the position as head of the Department of Electrical Engineering at the University of Vermont. Professor Edward Orton, Jr., who has been ab-

sent on leave for the past year, has returned and has taken up his duties as dean of the Engineering College and head of the Department of Ceramic Engineering. Mr. Horace N. Packard, formerly Assistant Professor of Experimental Engineering, has taken up University Extension Work under Professor Louis E. Reber, of the University of Wisconsin, with headquarters at Milwaukee. Mr. Alexander Vallance, M.E. 1909, who during the past year was Assistant in the Department of Mechanical Engineering, has accepted the position of Assistant Professor of Experimental Engineering for the coming year.

Purdue University.—Professor Philip S. Biegler, Assistant Electrical Engineer of the Washington Power Co., Spokane, Wash., has been secured to fill the place of Professor H. T. Plumb, who will be away on a year's leave of absence. Professor Biegler is a graduate of the University of Wisconsin and aside from his very valuable experience in the field in power station construction work, he has been employed three years with the Commonwealth Edison Co., of Chicago, and has been engaged in instructional work for three years at the University of Iowa where he held the position of assistant professor of electrical engineering. Professor Biegler will have charge of the electrical laboratory work and the courses in electrical engineering and power generation and distribution. Mr. C. W. Piper, who will fill the position of assistant in the electrical laboratory, is a graduate of Rose Polytechnic Institute with practical experience in the apprentice course of the Westinghouse Electric & Mfg. Co. and as assistant electrical engineer for Adams & Westlake, of Chicago, where he has been doing special research work on potential regulators for train lighting.

The following paper was presented at the eighteenth annual meeting, Madison, Wis., June 23, 24, 25, 1910. Written discussion is invited.

TEACHING ELECTRICAL ENGINEERING SUBJECTS TO NON-ELECTRICAL ENGINEERS.

BY C. FRANCIS HARDING,

Professor of Electrical Engineering, Purdue University.

The problem suggested by the above subject is one of the most important and difficult of satisfactory solution confronting the School of Electrical Engineering of the university with which the writer is connected, and for this reason, together with the fact that discussion of the matter with instructors of other universities has proven that the difficulties involved are not local, it is believed that a brief discussion of this problem may be of some value. Lest this matter, as inferred from the above subject, may appear too specialized for discussion before this Society, it should be pointed out that the problem is not confined to schools of electrical engineering but is met with by instructors in all of the engineering departments of most universities. As an example of this, the teaching of hydraulics to students who are taking electrical engineering courses and the instruction in many branches of mechanical engineering to either electrical or civil engineering students might be mentioned.

As the difficulties met with in administering such subjects as have been mentioned above may not be obvious to all at first sight, it may be well to mention, by way of introduction, those which are most likely to obtain in engineering schools.

First among these should be listed, in the opinion of the writer, the fact that the time devoted to the administration of electrical engineering subjects to civil and mechanical engineers is in most cases far too limited to do them justice. In many instances it is the belief of engineers in other fields of endeavor that a relatively limited course in electrical engi-

neering covering the description of electrical apparatus and some of its main characteristics can be given to advantage in a very short time and in this way fit non-electrical students to cope with problems which they are likely to meet with in the practice of their chosen profession. Those who are familiar with technical education, however, agree that memorizing of data and facts is of little or no value in solving the engineering problems of the future. Since no two similar problems are likely to arise, the young engineer must be trained in fundamental theory which will enable him to start the problem at the bottom, express it concisely in proper terms and solve it accurately. To give this training in fundamental theory requires a long and persistent drill in many fundamental principles which is not often possible in the limited time devoted to such subjects.

This leads us to the second consideration of lack of preparation. Students in mechanical and civil engineering have seldom had the training in electrical measurements in the department of physics that the electrical student has had and therefore, go to the electrical engineering course, difficult in itself to administer, with a weak foundation in the fundamental principles of the electrical circuit. The electrical engineering department must, therefore, begin with much more elementary work than with the electrical engineers and cover much less ground in a given time. Those who are particularly interested in the administration of the mechanical and civil subjects will appreciate that the training of the average mechanical and civil student in electrical engineering is quite analogous to the administration of the subject of railway construction without preparation in plain surveying and railway curves or the administration of mechanism without the fundamental training in dynamics.

The two other difficulties of this problem may readily be considered together as they both lead to the one result, *i. e.*, an indifference on the part of the student, especially in the senior year, towards subjects not closely allied to, and administered by the department in which the student is special-

izing. These difficulties might be defined as the desire for a superficial knowledge only of the subject as briefly alluded to above and a desire to specialize entirely in one's chosen field in the senior year. Unlike some subjects in the engineering curriculum, it is not difficult to impress upon the young mechanical and civil engineering student that a knowledge of electrical engineering is necessary in order to complete a well rounded development, but it is difficult for him to see the advantages of the training in fundamental theory over a descriptive course covering types of machines, efficiency, costs, wiring diagrams, etc. The average senior, in the technical schools especially, is usually particularly narrow in his ideas and tends to lay too much stress upon the specialized subjects in which he is particularly interested, at the time not realizing that the successful engineer must not only have a broad knowledge of the three branches of engineering being discussed in this paper but in addition a broad knowledge of human nature and the so-called culture studies.

If we now appreciate the fact that because of limited time, lack of preparation and lack of initial interest in the subject the successful administration of this subject forms a problem particularly difficult in solution, it is well worth our while to stop for a moment to consider the results which should be sought after and the methods of obtaining these results in the administration of courses subject to these difficulties. One of the important goals to be reached, if possible, in such training may have been inferred from the previous discussion, *i. e.,* the selection of these fundamental theories most likely to be encountered by the students taking the course and the limitation of the work to a thorough drill on the particular subjects selected, that is to say, we should aim at quality rather than quantity and by careful forethought eliminate much difficult work requiring long periods of time for its mastery, which, although of prime importance for students making a specialty of electrical engineering, is not likely to be encountered by the mechanical and civil engineer.

After the instructor has used his best judgment in selecting subjects of most value to be considered in the limited time and has used his best endeavors to teach the student to make similar selections in his later self development, the next step should be to train the student to select quickly the particular theory or principle with which he is familiar and upon which a given problem depends and then to apply this theory to the solution of his concrete problem. In the belief of the writer the great stumbling block in the path of the young engineer is the lack of ability to recognize the principle which lies at the root and forms the backbone of the problem; and, having found the principle, to express the concrete problem in correct mathematical terms.

The third ideal to be sought after, in the opinion of the writer, is the training of students to obtain accurate results. In reading the proceedings of this Society for last year, it was a pleasure to note the emphasis placed upon this point in at least one of the convention papers. It is a point likely to be emphasized more by the practical engineer and the technical instructor who has had a broad training in the engineering field than by the one who has remained in instructional work since graduation without sufficient personal contact with engineering problems. The engineer in the office and in the field demands results, and these results must be accurate. He is not usually greatly concerned with the methods employed in obtaining these results and has little patience with excuses and delays which sometimes enter in where only results are called for and expected. If, then, the mechanical and civil engineering student can be made to confine the only too limited time to the few fundamental principles which should be thoroughly grasped, to select the correct theory underlying the particular problem at hand, to be able to translate the conditions of the problems into mathematical terms and to manipulate these terms so as to arrive at a correct result, it is believed that the most satisfactory solution of this rather difficult instructional problem will have been found.

This discussion would hardly be complete without a mo-

ment's thought upon the methods which should be adopted in order to approximate as nearly as possible the goal outlined above. Again it is a pleasure to refer back to one of the very able papers in the PROCEEDINGS of last year and to call attention to the fact that little can be done, generally speaking, in the way of increasing the time allowance for such courses as are being considered in this discussion, for we soon find the curriculum limited on the one side by the entrance requirements which cannot be radically changed and on the other by the inability, sometimes physical and sometimes financial, of many students to take more than the four years course. If, then, we cannot expect to make any marked increase in the time available for such subjects, the only remedy lies in the increased efficiency of the administration. But how shall this increase in efficiency be obtained? Opinions differ widely regarding the relative value of recitations based upon text books, lectures and laboratory work and in many institutions the limited time available for these courses entirely eliminates the latter method of instruction. In the opinion of the writer no one text book, unless written by the instructor administering the course for the particular type of students in his institution, can possibly be satisfactory without a large amount of original thought and explanation injected into the course by the instructor. This seems to require, therefore, either recitations in which the instructor spends a comparatively large portion of the period in explanatory lectures or a course of combined lectures and recitations. It is believed that the latter plan involving lectures illustrated by tests upon typical modern apparatus in practical operation, together with recitations from text-books and practical engineering problems, based largely upon test data actually obtained during the lecture period, gives the best opportunity of approaching the goal which has been determined upon as most desirable. And right here, let me emphasize the value of problems of a practical engineering nature. Many are the problems given in electrical courses and, I am sorry to say, listed in many of the electrical text-

books which have little if any bearing upon the future work of the engineer. I do not wish to be interpreted as opposed to abstract problems for the purpose of mental training, for the writer is heartily in favor of a long and thorough training in such, but he does believe that this should be preliminary to and not a part of the purely engineering courses. This memory training should be obtained in mathematics, the sciences and humanities rather than in the engineering problems. It is believed that much of the criticism of the non-technical graduate from practical engineers and manufacturers is due to the fact that he has been led to believe by such abstract problems and by instructors not familiar with practical conditions that some of the abstract results obtained in undergraduate work have some bearing upon and basis for comparison with results which he is endeavoring to obtain accurately in his later professional experience.

If the methods outlined above are carried out, it is believed that not only will the student obtain a thorough training of some real value to him in after life, but he will incidentally be interested in the work and be able to see the value of the fundamental principles as applied to practical engineering problems in his future career not only, but also in his class room experiences. Let us, therefore, not neglect to recognize the difficulties of the problem but endeavor to determine what the most vital ones are in the particular institution with which we are connected, hold even before us the results which we would like to obtain, whether they be in accordance with the suggestions of this discussion or not, plan our courses to fit the limited time at our disposal, and yet thoroughly prepare the student along the lines most likely to be met with in practice by a thorough drill in carefully selected principles of fundamental theory illustrated by tests and problems which would be recognized by a man in the active engineering profession as having some bearing upon his work.

Written discussion on the above paper, if received before Dec. 1, will, with the approval of the Editing Committee, be printed in the PROCEEDINGS. Contributions should be brief and interesting and should add something to the subject.—ED.

The following paper was presented at the eighteenth annual meeting, Madison, Wis., June 23, 24, 25, 1910. Written discussion is invited.

CLEARNESS AND ACCURACY IN COMPOSITION.

BY JOHN J. CLARK,

Dean of the Faculty, International Correspondence Schools.

I make no apology for bringing to your attention what I consider one of the most important duties of an educator. You have already considered the question of poor spelling, and I agree that to be able to spell well is a valuable accomplishment. At the same time poor spelling is not one of the worst drawbacks to success. I once worked under a man (who by the way was a member of the American Society of Mechanical Engineers) who could not write five consecutive words and have them all spelled correctly. In fact his spelling was so bad that he asked me one day how to spell "got." When I had made sure that I had heard him correctly and had told him, he said in a tone of surprise: "That's just the way I have it, but it looks so damned short, I thought it must be wrong." His argument was: "Spelling is no science. If it were, I'd learn it; but as it isn't I'm not going to waste my time learning it, when I can hire you to do it for me."

Without dwelling on the merits of this argument, I can say without any hesitancy that if during the eighteen years I have been engaged in writing or in directing the writing of the text-books used by the International Correspondence Schools, poor spelling and bad grammar had been the worst difficulties I had to contend with, my work would have indeed been easy and my employers would have been saved more than a quarter of a million dollars.

The greatest obstacle we have had to contend with is the apparent inability of writers to express accurately the ideas they intend to convey, and this statement applies to college graduates, ministers, doctors, lawyers, engineers, college pro-

fessors, and to practically every one who has ever written manuscript for us. I use the words *apparent inability* advisedly, for whenever a man has been regularly employed in our Text-book Department for a few months and has had his work subjected to our criticism, his subsequent writings have greatly improved—improved to such an extent, in fact, that in a comparatively short time the only editing required was that necessary to secure uniformity in spelling and typography, and to make such improvements in grammar and diction as would naturally be suggested by a critical reader. Another common fault is poor arrangement of topics, with apparently no attempt to treat the subject in a simple, logical order. When two or more unrelated ideas occur in the same paragraph or in succession and the writer jumps back to the first one, then hops ahead to something entirely new, proceeding in this way all through the manuscript, it leaves the reader in a dazed state of mind, to say the least.

But when both of these bad features—inaccuracy of expression and poor arrangement—are present, one wonders if the writer ever had any training in composition, and if so, what manner of teacher did he have? Judging from my own experience, either the teachers are incapable of giving proper instruction or else they are so busy chasing split infinitives, the elusive comma, mixed metaphors, etc., that they overlook the fact that language is not an application of grammar, but a medium for expressing thought.

My object in bringing this matter to your attention is that I may suggest a change in the method of teaching composition to engineering students. Before doing so, however, I desire to fortify my argument by reference to a few actual cases.

About fifteen years ago I edited a manuscript on graphic statics. I was well satisfied with it, except for a paragraph of about 300 words containing a description of the application of Bow's notation to the stress diagram of a bridge truss. I did not seem to understand it, but thought perhaps that was because I had not read it with sufficient care, and I sent the manuscript to the printer. I read the galley proof after the

author, and for the second time I failed to understand that particular paragraph. I studied it for about two hours and then conceived a new and what I thought was an original idea. After referring to the various truss diagrams I evolved what I thought was a very simple and easy method of drawing the stress diagram. So I turned the galley over, wrote my description on the back, and took it to the author, expecting to be complimented on my discovery. He read it through very carefully, looked sad, and said nothing. I asked him if it was all right, and he said yes, it was just what he was trying to say.

Some time ago I wrote to a lawyer and asked his opinion regarding a matter pertaining to the law of copyright. This is the answer I received:

"MR. J. J. CLARK, Manager, Textbook Department.

Dear Sir: Your letter received, and I will write to Mr. Solberg with regard to the copyright question. The only thing it strikes me that when the Instruction Papers are copyrighted they are protected, but when they are bound in the Bound Volume form and a title page is added it protects the whole set. The question in my mind is whether or not there should be a title page filed with the first Instruction papers, or what will be the title page of the I. C. S. Reference Library. As soon as I get word from Mr. Solberg I will advise you. Respectfully yours."

I hardly think you will blame me for asking him to explain.

The following is taken from a manuscript written to explain some of the elementary principles of geometry:

"The size or *measurement of an angle* is of an entirely different kind and nature from the measurement of length and area. As was heretofore stated, length cannot be conceived of by itself, it is a mere comparison of at least two things to each other, of which one is an arbitrary standard. A degree of an angle is not an arbitrary standard, but merely a certain part of a perigon, so that: *The measurement of an angle is certain* and universal, on account of its certain basis. A perigon is as eternal in its nature as a geometrical principle; it is as it is because it cannot be any different; it always was the same, and can never be any different in the future. Anybody can make one, at any time, without reference to any other standard or anything else. Since the size of an angle is of a different nature from that of length, an angle cannot be measured by the length of any one line, nor can any comparison be made between the size of a surface or body and the size of an angle. *But, three lines having*

a definite relative length or proportion to each other, and placed together in the form of a triangle, define an angle, as will be shown in the chapter on triangles."

From a manuscript prepared by a young man, a college graduate of three or four years' standing, I copied this:

"Any owner of a gasoline engine, whose connecting-rod bearings will not 'stand up' should examine his crank-pins to see if they are round or not."

In the four cases just cited the editor would have a comparatively easy time, since the language is so obviously bad, that he can see at once something is wrong. But when the language is smooth and the facts are presented with apparent clearness and in logical order, the editor must be alert indeed or he will fail to detect the statements that will cause trouble for the reader. I shall give one example, taken from a work on storage batteries:

"The original lead accumulator, as made by Planté, consists of two plates of lead, usually rolled together in a spiral and separated by strips of rubber or other suitable insulating material, placed in dilute sulphuric acid. On sending a current from some external source through this cell, the water becomes decomposed . . . the oxygen combines with the positive plate, forming lead oxide or peroxide, while the hydrogen collects at the negative plate.

"On disconnecting the source of the applied current, and completing the external circuit of the cell, the water is again decomposed . . . the oxygen uniting with the hydrogen collected at the negative plate and with the lead plate itself, and the hydrogen uniting with the oxygen of the oxide of lead at the positive plate . . . thus producing a current in the opposite direction to the applied current."

This appears to be a clear, well-written, and concise description of a Planté cell. However, let us analyze it from the standpoint of one who has never heard of a storage battery, but is fairly well informed regarding primary batteries and electrolytes, and has been told that the positive plate is the one at which the current enters the cell when charging.

Consider the phrase: "two plates of lead, usually rolled together in a spiral and separated by strips of rubber or other suitable insulating material, placed in dilute sulphuric acid."

Does this mean that two similar flat lead plates are placed so that one of the surfaces of one touches a similar surface of the other, with their corresponding edges adjacent, and then both plates are rolled as though it were a single plate, after which strips of rubber are placed between the plates? Or are the strips of rubber placed between the plates before rolling? And are the strips narrow or wide? If narrow are they numerous or otherwise? Why use strips? Why not use sheets of rubber? Which way do the strips run—parallel to the axis of the coil or the same way as rolled?

Further on it is stated that "the water becomes decomposed"; where does the water come from? Nothing has been said about water. After wasting a certain amount of time on this, the reader may surmise that the acid was diluted with water and the water referred to is that contained in the solution.

In the phrase "forming lead oxide or peroxide" are two different compounds meant or two names for the same compound? If the former, the author should have written lead oxide or lead peroxide. Does the author mean that he doesn't know which is formed, that both may be formed, or that either may be formed?

Further on it is stated that "the water is again decomposed"; what water is this? If it has been decomposed once how can it be decomposed again? Where does this water come from? If only a part of the original water in the solution is decomposed in charging and another part in discharging, it will soon be exhausted, in which case is more water added or more diluted acid, and if the latter why?

The concluding phrase is: "thus producing a current in the opposite direction to the applied current." Why use the word "thus"? If "thus" were omitted, the remaining words would express a plain statement of fact; with the word in, however, the phrase expresses a conclusion from facts previously stated and which is supposed to be obvious to the reader. I do not think the author is justified in using the word in this instance.

I may appear hypercritical; but when I state that I have read the extract just quoted from twenty to thirty times, have glanced through the sections on electrochemistry and primary batteries, which the student is supposed to study before taking up storage batteries, and still do not thoroughly understand the author's explanation. I am sure something is wrong. What is the use of writing if you cannot make yourself understood, or, if your statements are liable to be misconstrued? The author of the foregoing extract was either very careless or else he himself did not comprehend what he was trying to describe.

This reminds me that for years I have had a strong suspicion that even Tyndale did not understand his subject on at least one occasion. On pages 135, 136 and 137 of "Heat a Mode of Motion," 6th ed., D. Appleton & Co., he attempts to explain why the temperature of air does not change when it expands in a vacuum without doing work, and then concludes thuswise: "All this needs reflection to arrive at clearness, but every effort of this kind which you make will render your subsequent efforts easier; and should you fail, at present, to gain clearness of comprehension, I repeat my recommendation of patience. Do not quit this portion of the subject without an effort to comprehend it—wrestle with it for a time, but do not despair if you fail to arrive at clearness." I can account for such a remarkable statement only by assuming that Tyndale was trying to explain something he did not understand, and my only comment is to quote Huxley, who wrote much and well on the subject of education: "A man can always talk about his own business. He can always make it plain; but if his knowledge is hearsay, he is afraid to go beyond what he has recollected, and put it before those that are ignorant in such shape that they shall comprehend it."—*Science and Art and Education.*

I now state as a general proposition: no one can write intelligibly on a subject he does not thoroughly understand; conversely, anyone having a fair knowledge of his native language and who is willing to be trained can be taught to

write intelligibly on any subject with which he is familiar. To this statement I would add another: Anyone who writes an article on any subject whatever so clearly that some one else ignorant of the subject can understand it will himself have a clearer insight into the subject than before. Granting that this is true why do we not make composition one of the most important features of our scheme of education? I again quote Huxley:

"I would assuredly devote a very large portion of the time of every English child to the careful study of the models of English writings of such varied and wonderful kind as we possess, and what is still more important and still more neglected, the habit of using that language with precision, with force, and with art. I fancy we are almost the only nation in the world who seem to think that composition comes by nature. The French attend to their own language, the Germans study theirs, but the Englishmen do not seem to think it is worth their while." Huxley—Science and Art and Education.

I give one more quotation occurring in a biographical sketch of Huxley, which appeared shortly after his death:

"To quote again the words of Huxley, which perhaps cannot be repeated too often: 'Good exposition implies much constructive imagination. A prerequisite is the forming of true ideas of the mental states of those who are to be taught; and a further prerequisite is the imagining of methods by which, beginning with conceptions they possess, there may be built up in their minds the conceptions they do not possess.' The distinguished author says further: 'Of constructive imagination as displayed in this sphere, men at large appear to be almost devoid.'"

It is of the utmost importance to the engineer that he have a clear comprehension of what he has studied, and he should be able to explain his thoughts and ideas to others clearly, simply, and forcibly. My experience has been that less than five per cent. of those who have assisted us in preparing our text-books have written their manuscripts in a manner that was passably satisfactory, unless they had been trained in our Text-book Department. They all have the following conspicuous faults: poor arrangement of subjects; carelessness in choice of words; carelessness in statement of facts; insufficient explanation; and an invariable tendency to forget that

the reader may not understand what is obvious to the author. This latter fault is perhaps the worst we have to contend with.

I can make myself clearer by citing a specific case. I recall that about fourteen or fifteen years ago one of our writers had occasion to describe how drawings and maps are colored, and gave some of the leading color combinations, such as, that yellow and blue make green, etc. I had never done any work of this kind, so I asked him if one color was ground in water, like India ink, and then the other color ground in until the desired secondary color was obtained, or if the colors were ground separately and mixed. I further stated that I couldn't see how the exact shade wanted could be obtained. He said "O! no! that is not the way: you paint one color on, and then you paint the other one over it." I am sure that would never have occurred to me from anything I had ever read. I was quite interested, and asked him if it made any difference which color was applied first. He said "No!" I then told him to put in his manuscript what he had just been telling me, as most of the students who studied his book would be fully as ignorant as I had been.

Present conditions would be greatly improved if every student throughout the entire four years of his college course, and at least as often as once a month, were required to submit a composition relating to some engineering subject he was then studying or had just finished. It should be distinctly understood that the article be prepared with the same care as would render it acceptable to the readers of a technical journal. When written it should be submitted to the professor in whose department the subject is taught, and he or one of his assistants should read it in order to be sure that it contained no technical errors, to make certain that the student understood the subject, and to obtain the student's point of view. It would then be well to send the article to the department of English for criticism as to grammar, spelling, punctuation, style, etc. The more expert the student becomes as a writer, the more thorough should be the criticism of his

written work. The student may have his subject assigned to him or he may select it himself, but in the latter case his choice should first be approved by the professor in whose department the subject is taught. For example, suppose the student were studying strength of materials and had completed the subject of flexure of beams. The professor might require him to write an article on the moment of inertia and radius of gyration, instructing the student to explain in a simple manner the meaning of these terms in relation to masses and how they enter into the theory of beams. Or, the student might be required to write a composition covering some subject to be selected from between certain specified pages of a particular text-book.

The adoption of a plan of this kind would achieve several purposes: It would compel the student to think; it would reveal whether or not he really grasped the subject; it would teach him to study his lessons more thoroughly and with keener relish; and it would enable him to appreciate more fully the beauties of his native language in addition to learning how to use it to secure the best effects.

It might seem that this will entail a large amount of work by the teaching staff. It certainly will in the case of new students; but after the third or fourth effort, provided the work of criticising has been done thoroughly and conscientiously, the student will have become imbued with the spirit of the work, and the labor of correcting his compositions will be very much lessened. I know this to be so from my own experience. When I was editing a technical journal that we formerly published, an article of about one thousand words and on a subject concerning which I knew nothing, was submitted by one of our text-book writers. The author had never been to college, his English was vile, and the article was the worst of any I have ever read. I criticized it in a general way and made him rewrite it; I did the same thing again, and for the third time. Then, having the facts so I could understand them, I rewrote the article myself, had him read it to make sure I had made no errors, and sent it to the printer.

His second article he rewrote but once; his third and fourth I simply edited and sent to the printer; his fifth article I sent to the printer without reading. Within about three months he was one of the best writers I had. It should not be forgotten, however, that he was thoroughly familiar with his subject.

Written discussion on the above paper, if received before Dec. 1, will, with the approval of the Editing Committee, be printed in the PROCEEDINGS. Contributions should be brief and interesting and should add something to the subject.—ED.

The following paper was presented at the eighteenth annual meeting, Madison, Wis., June 23, 24, 25, 1910. Written discussion is invited.

NOTES ON THE GERMAN TECHNICAL UNIVERSITIES.

BY GEORGE H. SHEPARD,

Dean of the L. C. Smith College of Applied Science, Syracuse University.

Introductory.

During the summer of 1908, I had the pleasure of visiting the German technical universities at Hanover, Charlottenburg, Dresden, Munich, Karlsruhe in Baden, and Aachen or Aix-la-Chapelle. My observations were primarily for the benefit of the university to whose faculty I belong, but, in the hope that they may be of wider use, I submit this paper to the Society. Beside the six schools above mentioned there are three others of the same rank, situated at Brunswick, Stuttgart, and Darmstadt, but lack of time prevented me from visiting these three schools. However, the nine universities are uniform to the extent that their requirements for entrance and for the first degree are substantially the same, and that each accepts the others' first degree as one of the prerequisites for its own degree of doctor-engineer. Enough uniformity is also maintained so that students can readily transfer from one to another; but, within the above limits, not only the faculties are autonomous, but even the individual heads of departments have great freedom in their methods and procedure. For the sake of brevity the methods which I observed will be here spoken of as "German," though the word is used in a qualified sense on account of my lack of opportunity to visit three of the universities, as above stated. I must state my indebtedness and express my thanks to many German professors, engineers, and students for very kind assistance, especially to the Verein Deutscher Ingenieure and to Dr. Franz Erich Junge, who was untiring in his efforts on my behalf.

The German technical universities are much wider in their scope than is usual with our engineering colleges, having departments of architecture, of chemistry, and, in some cases, of agriculture, forestry, and mathematics and general science, as well as of the subjects that are commonly taught by our own engineering colleges. I confined my own attention to the work in engineering, from lack of time, and because the other subjects were outside of my own duties and responsibilities. Statements made in this paper therefore refer only to instruction in engineering. This restriction should be noted, because some of my statements would not be true of the work of other departments.

PART I. THE STUDENTS.

The differences between the German methods and our own arise fundamentally from three causes: (1) The German student has had a more advanced entrance preparation than the American; (2) the German student is older and more mature while taking his technical course; (3) the German system, perhaps unconsciously, is designed to develop the best men to the utmost, with little regard to what becomes of the rest, while the American system is intended to make industrially valuable engineers out of as much as possible of the raw material that comes to it.

As to entrance preparation, in order to be admitted to a German technical university as a regular student and candidate for its first degree, the applicant must present the final diploma of a German secondary school, or its equivalent. The secondary schools that regularly prepare for the technical university are of three classes, the gymnasium, the real-school, and the ober-real-school. These follow the primary school, in which there is a course of four years, and themselves have courses of nine years. The gymnasium has a classical course, with great stress on Latin and Greek; the real-school has Latin but no Greek, and is more mathematical and scientific; while the ober-real-school has neither Latin nor Greek, but is strongly mathematical and scientific, and pays more attention

to modern languages than do the others. In addition to the scholastic requirements, electrical and mechanical engineers, in order to be admitted to the examination for the first degree, must have had at least one year of practical experience. Though this is not an entrance requirement, the circumstances are such that it is very advisable for a student to take most of it before entrance; and many students do so. This arises from the compulsory military service. A man of even less education than is required for entrance to the technical universities is let off with only one year of service with the colors; but thereafter he has to serve for two years in the reserve, returning to the colors for about two months each year. The obligation to serve in the reserve is apt to interfere with the graduate's securing a position, because employers dislike to take on a man who must be away from his work for two months each year. Hence, unless the student aspires to become an army officer, it is to his advantage to begin his military service not later than between the second and third years of his technical course. He will then be able to complete his reserve service, at or immediately after finishing the normal four years of resident study in his technical course, and to enter his professional career free, except in case of war, from military duties. This leaves free for the year in practice only the summer vacation between the first and second years, and in fact the rules of some of the technical universities allow only half of the year in practice to be done during the summer vacations: so that a student is obliged to do at least half a year's practice before entering, if he wishes to complete his course in the normal time; and many students do the whole of the year's practice before matriculating.

As to the nature of the practical work, experience in a manufactory engaged in building machinery, especially engines, turbines, electric machinery, or machine tools, is preferred; but great liberty is allowed. For example, a student may spend his entire year of practice in a smelting works or a steel works or as a marine engineer. If he wishes to specialize in textile work, he may take his entire year in a textile

mill. Also part of the year's experience may be taken in a power plant, or as a locomotive firemen or engineer. Fortunately, the industries realize the importance of the practical training of their future officers and many works cooperate with the schools by providing courses for their benefit. It is rare that the student workman receives any pay while engaged on such a course. On the contrary he usually has to pay for the privilege of taking it. In such courses the student is shifted through the whole plant, and is given opportunity to study all of its processes and methods that are appropriate for his instruction. In order to get credit for his practical work, the student must bring a certificate from the employer. "This certificate must show that the candidate, during his year of practice, has submitted without exception to the rules of a factory or other industrial enterprise, and must clearly show the kind of work upon which he has been engaged during the term in question."* It is evident that a student who is in earnest and appreciates his opportunities, may, under this system, obtain an excellent education in shop methods and processes, and may besides make himself a fair workman.

The student who has passed nine years of the German secondary schools has been carried considerably further than the graduate of our high schools. Assuming that he has also had at least half a year of a good shop course, I estimate that he could enter an American engineering college of the first rank as follows: (1) From ober-real-school, as a sophomore; (2) from real-school, as a freshman, with one semester's work already passed; (3) from gymnasium, as a freshman, with freshman shop already passed and with already considerable knowledge of the freshman mathematics. Besides this the gymnasium student would have had a long and thorough training in Latin and Greek; and, while other studies would probably be a better preparation for the technical course, still the value of the study of these highly inflected languages in developing ability to think systematically can not be denied.

* Munich, Regulations for Examination of Mechanical Engineers for the First Degree.

It will be noted that the German entrance requirements are severe. Even under our somewhat easier conditions we find it advisable to open the doors of our engineering colleges to men who, while they may have been barred from obtaining the book knowledge which we require of candidates for a degree, are capable of becoming able engineers. This we do by admitting special students, who are usually required to be men of at least twenty years of age who have been unable, by reason of poverty, to make the regular entrance preparation. With us, such students are usually allowed to take any course which their previous knowledge enables them to handle; and, while they receive no degree, they are often among the best engineers produced by our schools. We are apt to regard such a plan as peculiar to our democratic effort to give every man his chance, and I was therefore interested in discovering fully as liberal a scheme in operation under the imperial government and aristocratic social organization of Germany.

The German technical universities admit as "hearers" persons who are not able to fulfil the regular entrance requirements, but who possess the necessary education for admission to the one year military voluntariat. This allows the omission of the last two years of the secondary school. In Prussia the "hearer" must have the diploma of a manual training high school of the building trades and one year of practical experience. If the German requirements of the "hearer" are more severe than ours of the special student, the former gets more for it, since he receives an official certificate of attendance, while the American special student usually gets no official evidence whatever of his studies. Also the German technical universities admit to single courses as visitors, persons who are unable to fulfil the entrance requirements. Visitors are usually required to be men of mature years. Ordinarily they receive no kind of academic certificate for their work, but at Munich they can obtain reports of having passed individual courses. Not only this, but there is a system of scholarships by which a poor boy of ability can obtain financial help, from the beginning of the secondary school through to the completion of his education.

It is evident that the German engineer must be rather older than our men, upon entering his professional career. Assuming that a boy enters school at six years of age and thereafter advances at the normal rate, without interruptions of any kind, his age and progress would correspond about as follows:

	Years.
Age on beginning school	6
Time in primary school	4
Age on entering secondary school	10
Time in secondary school	9
Age on completing preparatory education	19
Time in technical university	4
Time in military service	1
Age of civil engineer on beginning professional carreer	24
Add for practical course in industry, for electrical and mechanical engineers	1
Age of electrical or mechanical engineer on beginning professional career	25

While the time in practice and in military service can to some extent be telescoped with the time in the technical course, on the other hand about three months should, in most of the German technical universities, be added to the four years allowed for the course, for the "diploma-task," of which more hereafter. Hence I believe that the table will represent pretty close to the general minimum of age. Of course, an occasional brilliant student may get along faster; but to attain even the rate of progress shown, one must, from beginning to end of his education, combine good mental ability, sound health, and financial means sufficient for his living and education. Further, though the graduate apprentice course is practically non-existent in Germany, the German technical graduate must enter the industries in a position very little better than that of a graduate apprentice; and at the outset, will not earn more than twenty-eight to thirty-six dollars a month. Consequently he will not have attained enough income to marry, until he is twenty-seven or eight years of age at the youngest, while most men will be considerably older.

Similarly estimating minimum ages for the American, we have:

	Years.
Age on beginning school	6
Time in primary, intermediate, and grammar schools	8
Time in high school	4
Age on completing preparatory education	18
Time in technical college	4
Time in graduate apprentice course	2
Age on beginning professional career	24

It is apparent that the American engineer will take a responsible place in the profession and in the community at a somewhat earlier age than the German, and this is an advantage that should not be lightly sacrificed. To say nothing of the comfort and happiness of the individual, it is to the distinct advantage of the industries if their junior officers can come to them at an age when they are still young enough to be adaptable. Further, late marriage of men is a fruitful cause of immorality, and the effects of this in producing national degeneration are too well known to require discussion here. Whatever good the Germans may obtain from the more advanced entrance preparation of their technical students, we can also obtain, when occasion demands, by raising our own entrance requirements; but, as long as our own system produces graduates that are able to fill the positions that are waiting for them, and to keep our industries on a par with those of other nations, I believe that we should be very careful how we do anything that would postpone to a later age the time at which our graduates can become self-supporting members of society. As has been stated, the German is better prepared for the technical courses, and he is also older and more mature than the American during his time as an undergraduate. The electrical and mechanical engineer usually has the advantage of a year's practical experience. Further, as has been shown, during the latter half of his course at least, the German student probably has behind him a year of military service.

The military service probably has much more value to the student than we Americans commonly attach to it. The soldier's life builds up the student's health and teaches him to be orderly, neat, and systematic. Besides, the engineering student may combine military service and practical experience by serving in the engineer corps of the army or in the railroad regiment, which is always in charge of the operation of part of the state railroads of Germany, or by serving as a military telegrapher, aeronaut, or chauffeur. More important, in military service the student may learn organization, discipline, administration, and the handling of men.

Receiving its students under the above conditions, the technical university assumes that they are mature men, that they know what they want and intend to get it, and that in all ways they are perfectly able to take care of themselves; and proceeds to deal with them accordingly. Instruction is given at scheduled times. If the student wants to attend he does so; if not, he stays away. If he wants to take a course, he records it in his course book, gets the professor in charge to countersign it as his official evidence of having registered; and thereafter nobody, except himself, cares, or even knows, whether he attends the course or not. At the end of two years he has an opportunity to obtain official credit for the courses that he has taken up to that time by passing examinations in them; and at the end of the course he has a similar opportunity to get credit for the work of the last two years. To enter the examination in any course he must produce his official evidence of registration. After that it is up to him to pass the examination. Nobody asks whether he actually attended the course. It seems to me that the institutions are hardly justified in their assumptions. In the secondary schools, the students have been worked to a degree of which our high school students have no conception. Besides, they have been kept under a system of regulation and discipline at once iron-clad and minute. If a year in a works has intervened, the student has there also kept factory hours and been under rigid factory discipline. From this he comes into absolute freedom in the

technical university. Considering that he is still an immature boy in his early twenties, it is not surpising that the effect of the sudden release of pressure is, in many cases, an explosion. Often the boy goes in for a good time, for drinking, duelling, and the life of the student clubs, and even for dissipation; and throws study to the winds. The day of reckoning is far off, and even for that genial gentlemen are ready to prepare him. Every institution of learning has its unofficial staff of crammers, who, like the camp followers of an army, prey upon the fallen and the stragglers. These people make it their business, not to teach, but to prepare for examination. Since teachers, being human, have their fads, and the students' mind can retain for a short time a vast amount of undigested and unassimilated learning, it is evidently possible for a professional crammer to get a student through an examination with remarkably little real knowledge of the subject. Even if the student fails to pass the examinations, it brings upon him no punishment from the institution. He has to take the examination again at some future time; and, unless his family calls him to account for his failure, that is all there is to it.

Contrasting with this the American system, our students come to us already accustomed to a large amount of freedom, and they know how to conduct themselves under it. Notwithstanding this they are not turned so absolutely loose as the German students. Our students' work is noted from day to day and a continuous record is kept of it. Examinations are frequent; and, at the end of the semester, a student who has made a very poor record is dismissed, both to keep the resources of the institution from being wasted on an unfit subject and to protect the student and his family against his wasting his time and money on a profession that he either can not, or will not, learn. In fact American engineering faculties feel that they are responsible for their students and that they owe it to them and to their parents to see that they either make good use of their opportunities or cease to waste them under the protection of the college. The Germans claim that our system makes the student dependent and morally

weak. I feel that in this they are mistaken. The abuse of our system might do so, but the system itself does not. Our students are treated as men and are not denied that freedom to fall which alone can develop ability to stand; but the fall is not allowed to be so long postponed that the student forgets that it will ever come; and the discipline, by being promptly administered, can be given in a small dose, which is curative, rather than fatal, in its effects. As for those German students who at the outset devote themselves to pleasure to the neglect of their studies; in some of them the racial characteristics assert themselves and, after a period of hilarity, they settle down to work and complete the course; but many of them drop out and never take the degree. Of these, most are absorbed by the industries in minor places and probably never rise above draftsmanships and similar positions. Some, of course, who really have talent, do better and rise to good positions, in spite of the mistakes of their student days. The Germans claim for their system that it develops men who are strong and self-reliant. Doubtless it does so, in the case of those who survive it; but it seems to me very much like the Indian method of building a strong physical constitution. A full-grown American Indian can stand anything, simply because no Indian who could not stand everything could possibly live to grow up. It seems to me that our system develops men who are fully as self-reliant, and at the expense of much less waste of student life. Concentrating our attention upon the German students who are faithful to their professional studies, in spite of all temptation to be otherwise, and for whom the system seems to be devised, it appears that they enter their technical studies with more advanced preparation than do our students and with the further advantage of having shopwork eliminated from their college course. It may be asked in what respect the technical education received by these men differs from what the American institution gives to its students.

In the education of the German electrical and mechanical engineer the year of practical experience exercises an influence

over the whole course, which requires further discussion. It will be unnecessary to say to the Society that the experience enables the student more easily and better to understand and appreciate all the technical instruction of the school. On this account it enables the work of instruction in parts to be abbreviated. The year in practice also gives the student a chance to find himself, to learn his own tastes and capabilities, and to estimate the opportunities that are open to him. It therefore enables the work in the more advanced professional subjects to be more closely directed to the object in view, that is to be more specialized. Also, because the four years' course is relieved of shop work, time is available to lay the foundations of technical education somewhat more broadly than with us. Further, from the same cause and because the pure science and mathematics of the first years are partly a review of the work of the secondary schools, more of the purely professional work is put into the first two years than with us, and this relieves the pressure of the last two years, which with us are very crowded, and enables the student to do his most advanced professional study in a less hurried fashion. To illustrate, every American teacher of machine design has probably been perplexed by the question of detail drawings. When a student has worked out the main features of a design and is making his assembled drawings, the question always arises as to how far he should be required to make the detail sheets. I think that any experienced teacher will say that these details consume a vast amount of the student's time, and that he learns comparatively little from them in proportion to the time spent on them. At the same time, students inexperienced in actual construction can not judge of the practicability of their details except by working them out on the drafting board, and an impossible detail may throw out some of the main features of the design. For this reason the American teacher is obliged to give his pupil as much detailing work as can be done without losing too much time from work on the broader features of design. On the other hand, in visiting the drafting rooms of the German technical univer-

sities, I found the detailing work, while not absolutely eliminated, still reduced to a minimum, and to very much less than would ordinarily be required in an American college drafting room. It is evident that the German student, with his experience in actual practice, does not need so much detailing work, and that he can consequently save the time for more important work.

Nominally the course offered to the German student is purely elective. To the best of my knowledge, an entirely elective course has never found favor in our technical colleges; and our liberal arts colleges, having tried it, have found it unsatisfactory and are working away from it. It is interesting, in view of our experience, to note that the Germans, while apparently offering the student a free choice of any subjects that he wishes to take, immediately hedge by requiring him to pass an examination in certain subjects, and in limited alternatives to some others, as a condition of receiving the first degree; and the amount of work thus required is enough to occupy nearly, if not quite, all of a student's time for four years: so that, unless he wishes to take a longer course or to sacrifice the degree, he finds himself restricted to practically a prescribed course, the same as do our students. The course thus laid down, if the year in practice be taken as the equivalent of our shop-work, does not differ materially from what a student would get in an American technical college of the first class. In some respects it is broader than our course. Thus among the required subjects of the Charlottenburg course for mechanical engineers, we find elements of underground and overhead construction and design of hydraulic prime movers, both of which we are commonly obliged to leave to the civil engineers, and political economy, of which our students generally hear nothing after they leave the secondary school.

At the same time, the German course is in some ways more specialized than ours. Thus at Charlottenburg, there are allied with the general mechanical engineering course, courses for transportation engineers and managing engineers. The

course for managing engineers branches off in the third year and thereafter pays more attention to economics, commerce, patent law, languages, and hygiene than does the general course. The course for transportation engineers branches off in the fourth year, and thereafter pays more attention to roads, stations, bridges, and signals than does the general course. At Dresden the mechanical engineering course divides into courses for machine engineers and for factory engineers; and the civil engineering, into courses for construction engineers and for surveyors. Even at Munich, where close specialization is avoided, civil engineering is thus divided; and, beside the course in mechanical engineering, there is a course in technical physics. Also, within the regular courses, the amount of election allowed by the requirements for the first degree, though limited, still permits a yet closer specialization. Thus, at Charlottenburg, in the regular mechanical course, each student designs one gas engine or one piston steam engine or one steam turbine, one machine tool or one hoisting engine, and one water turbine. To take an extreme case, suppose that a student should elect to design one compound stationary steam engine, one hoist driven by simple steam engines, one water turbine, and, as his diploma task, which is completely elective, one triple expansion marine steam engine. Such a student would have acquired a large amount of practice in the design of the piston steam engine, but would be completely lacking in designing experience on internal combustion engines, steam turbines, and machine tools.

At first thought such close specialization is very attractive. In the education of every engineer there must first be a foundation of general mathematics, science, and shop practice. Then there are certain technical subjects of which the need is so common that no engineer should be ignorant of them. For example, every engineer uses steam engines, and should have at least enough knowledge of them to enable him to exercise a general supervision over their operation and maintenance. Following these come the courses in design and in the engi-

neering laboratories. In these the field is so vast that it is obviously impossible for the undergraduate to get more than a limited detailed experience of them. Hence the value to a student of working out any given problem, for example, the design of a machine tool, consists more in the exercise of his faculties in the solution of a practical designing problem, than in the knowledge acquired of that particular tool, because he will probably never again have to design that tool. Also, exercise in design may be as well obtained on one problem as another, and in this respect there would be no choice between the student's designing a machine tool and his designing an automobile. At the same time, in order to be a practical designer, a man must have a large fund of empirical knowledge which can come only from extensive experience of a limited field. Hence the student will be nearly as well grounded in the theoretical basis of design, and will be a more practical designer in a certain line, if his undergraduate practice has been specialized therein. Similar considerations apply to the work in the engineering laboratories.

The trouble with close specialization on the part of the undergraduate is that his future opportunities can seldom be foreseen. I remember a young American engineer who, in college, specialized very closely in hydraulic engineering. On his graduation he found it impossible to get work in that line. After several months of unsuccessful effort, being absolutely obliged to begin earning something, he applied to a ship-yard for any kind of work; and was given a job in the ship-fitter's gang. Of course his special studies in hydraulics were of no use to him there, and only the general foundations of his technical education applied at all. Obviously he would have been better fitted for the work in which he actually landed, if his technical course had been more general. I met him several years afterward, and found him still working at ship-fitting. He told me that he had learned enough about it, so that he could earn a living wage, and that he expected to stick to it. In all but a few cases, both our students and ourselves are completely in the dark as to what their opportunities will be.

Under these circumstances I believe that we serve our students' interests better by preparing them to take positions of about the grade of a graduate apprenticeship over as wide a range of industry as possible, than by trying to fit them to enter at once a higher position in some specialty. This necessarily does away with close specialization for the great mass of undergraduates.

I am informed that the Germans find somewhat the same difficulty in fitting specialization to the student's opportunities; but I believe that it works somewhat better with them than it would with us, on account of the year of practical experience on the part of their electrical and mechanical engineers. I think that we should receive even greater benefit in this direction from such a requirement, because, under our conditions, the year of experience would be actual work and not a course of instruction. In such a year of work a student would tend to find what his capabalities were and for what line of work he was best adapted; and satisfactory service for an employer in a certain line would open to the young engineer further opportunities in the same line, if not with the same employer, with others through his recommendations. I therefore believe that a year of practical experience on the part of our students would enable them to specialize somewhat more closely than they now do, without prejudice to their future opportunities, but rather with the result of fitting them better for those opportunities and of enabling them sooner to become valuable to their employers and to themselves.

Notwithstanding the benefits of adding the requirement of the year in practice to our present ones for the first degree, this addition can not be made all at once; but I believe that we should work in that direction as fast as we can. In this we are dependent upon engineering employers, and I hope that this paper may draw discussion on this point from the gentlemen without whose cooperation we can not secure the desired experience for our students. If the year in practice would mean that our students must be that much older on beginning their professional careers, that would be a serious

objection to its adoption; but such is not necessarily the case. In order to arrive at a table of minimum ages, we may assume that a boy will work for six months in engineering practice between the high school and the engineering college. We might assume that he could do these six months during the summer vacations of the high school, but I shall not go to that extreme. The other six months could be done during the summer vacations of the college course. At this stage the student would be sufficiently advanced so that he could profit by the fact that many large concerns allow vacation work to count on their graduate apprentice courses, and he could thus shorten by that amount the length of his apprenticeship. We should therefore have, as the minimum possible ages:

	Years.
Age on beginning school	6
Time in primary, intermediate, and grammar schools	8
Time in high school	4
Time in practical work	.5
Age on entering technical college	18.5
Time in technical college, including six months of practical work	4
Time in graduate apprentice course	1.5
Age on beginning professional career	24.0

This gets the young engineer into his career at the same age as at present, with the benefit of six months more of experience, and with a better preparation by the technical college because of the practical experience taken in connection with its course. Under our conditions our students must do work on which their employers make a profit, in order to have their presence tolerated in an industry, instead of being under instruction for which they pay, as in Germany. Therefore the tasks of our students while in practice must be sufficiently specialized to enable them to work with some skill, and this will prevent their obtaining as general knowledge as is desirable. For this reason I believe that our present college shops and the courses in connection therewith cannot be done away, but must be used to give the students the broad knowl-

edge of shop processes that they cannot get in the industries; while the latter give them the practical experience that they cannot get in the college. I hope, however, that we may be favored by some discussion from persons who are acquainted with the interesting methods of instruction now being followed at the University of Cincinnati. Conversely, as long as the college shops are maintained, I believe that we might make an allowance as to acceptance of practical work even broader than do the Germans. My present suggestion would be to accept anything that might be considered engineering work, even engineering salesmanship, giving the student the broadest opportunity to find himself, to gain experience of life, and to learn the line of work for which he is adapted. I should not, however, recommend leaving the inexperienced student without guidance. To help him to find out his own capabilities, to aid him to secure employment to which he is suited, and to guide him into it, I should, following a suggestion made to me by Mr. George DeA. Babcock, former professor of Practical Mechanics in Syracuse University, recommend putting the whole matter under the supervision of a committee of the faculty.

To make sure that the student would make good use of his opportunities while in practice, I should recommend, still following Mr. Babcock, that the same committee of the faculty should conduct correspondence courses with those students who were engaged in practice, on which the students should be graded the same as on any other course in the institution. The conduct of such correspondence courses will be a matter of some difficulty. A student might easily be harassed by unreasonable nagging of a distant professor, into a state in which he would be utterly useless both to his employer and to himself, and thus miss one of the most valuable features of such work, which is the discipline of working under the requirement that he *must* produce the value of his wage, plus a profit to his employer. I have never taught such a course and therefore shall not undertake to say how it should be done, but I should begin by requiring each student to send me a

brief report at the end of each week's work. As long as his reports showed that he was reasonably alert, observant, and faithful to his employer, I should not trouble him with anything further. If they failed to show this, I should ask him some questions, to answer which he would be obliged, without neglecting his work, to notice that work and what went on about him and to reason upon what he observed; and I should also try to rouse him to his duty to his employer. I realize, of course, that preliminary suggestions must be tentative, that we must feel our way and be guided by experience. Some of our technical colleges have already started in the direction indicated, and my personal opinion is that the rest of us ought to follow their example.

It has been pointed out that the work of the German student is somewhat less crowded than with us, especially in the professional studies of the latter half of the course. It is proper to inquire in what way the Germans profit, as compared with us, by this greater leisure. The Germans claim special thoroughness for their work; and, as they have a general reputation for this excellence, and thoroughness is generally considered to be a peculiarly German virtue, this claim may in general be allowed, in so far as the conscientious and earnest students are concerned. My own information is to the effect that this varies greatly with different institutions and with different professors. As to those students who devote themselves to pleasure and pass their examinations on the strength of a crammer's course, it is unnecessary to discuss thoroughness in connection with them. The Germans claim that thoroughness is produced by two causes: (1) The placing of the student on his honor by giving him complete freedom; and (2) the extensive use of practical exercises, both in the laboratory and in the drafting room. As to the first cause, it doubtless produces the desired effect in the work of those students who are earnest and conscientious in the face of the abundant opportunities to be otherwise. Whether their work is more thorough than that of our own students of the better sort, I am not prepared to say. If so, we compensate for it

by getting more out of those students who would go to pieces under the German system. At any rate I feel that our own methods should not be conformed to the German model in this respect. As to the use of practical exercises, whether in the experimental problems of the laboratory or in the designing problems of the drafting room, in them a student has to apply the knowledge which he has acquired in the lecture room. The effort to apply clarifies the knowledge itself, besides revealing its defects and developing the ability to make practical use of what one knows. It is unnecessary to discuss at length the necessity for a large use of practical exercises in the education of the engineer, because that necessity has been generally recognized in this country, and the practice of our engineering colleges is in accordance with it.

I was interested in trying to find out how extensively the Germans use practice work in comparison with our schools; but, in the limited time at my disposal, I found it impossible to get enough first hand figures to warrant a generalization. The subject is complicated by the large number of different courses offered and the opportunity, though limited, for election within courses. Professor MacLay, of the University of Glasgow, in an article on the German technical universities published ten years ago, gives for the nine German institutions figures for the ratio of time spent by the student in practice to time spent in instruction in theory, of which the average is 1.28. Such figures as I was able to obtain show a much less value of this ratio, unless the year in industry is included as practice work of the course, in which case my figures check Professor MacLay's very well. It is only fair to include the year in industry as practice in the German schedule, because it take the place of our shopwork, which would certainly be included in the practice of the American schedule. There are probably few American technical colleges whose ratio of practice to theory could approach this figure for the four years' course alone. On the other hand, if two years of graduate aprpenticeship are included in the American course as practice, our ratio of practice to theory

would greatly exceed the German. Doubtless our men would be improved by more practice, if they could get it without too great sacrifice of theoretical instruction. My own observation of the work of our technical colleges leads me to believe that the time which we devote to theory has already been cut down to the limit; and I therefore see no way in which more practice can be squeezed in except by the adoption of the German requirement of the year in industry, for which I have proposed a plan above. On this point it should be said that the Germans consider one of the strong points of their system to be the broad and thorough instruction in fundamental theory; and that they believe, and I think rightly, that it is better to ground a man thoroughly in the theoretical foundations of engineering, to give him enough practice to enable him to apply what he knows, and then to leave him to work out his own problems as they arise, than to send him out equipped with a vast amount of knowledge of practical details, which must be largely empirical and superficial, even if it is confined to a narrow specialty.

The Germans claim, as a virtue of their system, that it develops men who are self reliant and capable of independent work. Probably many members of the Society know better than I, to what extent this claim is justified. As to the means by which this strength is produced, the Germans attribute it first to the system of general student liberty which has been discussed above, and second, to the large use of the problem method in instruction. A large part of the practice work above mentioned naturally consists in the solution of problems; in the laboratory, by experimental methods; in design by calculation or graphic work on the drafting board. In the German technical universities, after a problem has been assigned, the student is left pretty much to himself in the solution of it. This is done because it is held that the student develops more independence by being thus let alone, and because the faculty is too much occupied otherwise to give him much attention. More will be said later on this point.

If in the above I have appeared to criticize the German sys-

tem in some points, it is only fair to judge the system by its results. If we consider the highly skilled engineering work of the Germans and the great advances that their industries have made in the last thirty years, it is evident that they must be officered by men who have been well trained for their life work. On the other hand, if we apply the same test to our own technical colleges, the result is equally satisfactory. If the Germans have done better than we in some points, in others we have done better than they; and each nation has done its best work where its necessities were the most pressing, so that comparative excellence is evidently a matter of environment rather than of superior ability. Still it must be remembered that ours is a four years' course, while the German course, at least for electrical and mechanical engineers, amounts to five years; and it may well be asked how we are able in four years to equip our students substantially as well as the Germans do their better prepared students in five. To some extent it is a matter of racial temperament. The German is the more careful and painstaking; the American is the quicker and more alert; but, even allowing for this, to coach the American boy along at the greater rate of speed, and still not to help him enough to keep him from developing the self reliance which is one of the boasts of the German system, require teaching skill and hard work on the part of the American faculty. Hence American teachers of engineering are much more burdened with the details of instruction and administration than are the Germans; and this is an important point, which will be further discussed.

On the whole I think that a young American would gain nothing by going to Germany for his first degree in engineering. On the contrary, unless he speaks and understands German fluently, and is a man of much strength of character, I think that he would do much better to study in this country. I make this statement with full appreciation of the fact that the equipment of the German technical universities is superior to that of most of our institutions. It is inevitable that, to serve our much more scattered population, we should have a

larger number of smaller institutions and that the equipment of each of these should be less than if they were all concentrated into a few great universities. However, it does not take a great laboratory to give the undergraduate all the work that he can profitably attempt. As for models, they help to illustrate; but, lacking them, a scientific principle can be studied from the text-book with the aid of the drafting board, though at the expense of greater labor on the part of both teacher and pupil.

In view of our generally unsatisfactory experience with the undergraduate thesis, I was surprised to find that most of the German technical universities require what amounts to the same thing, for the first degree. The reasons for the difference between their experience and ours may be of interest. Giving a four years' course, we have usually allowed for the thesis only about four semester hours. It is very difficult to find a subject for a thesis small enough so that it can be well handled in this limited time. Further, there has, at least in my own experience, been a general ambition among undergraduates to attempt, as a thesis, something in the way of research; and this has been generally encouraged by their teachers, though undergraduates are almost always professionally too immature to do research. Under these conditions our students have generally attempted as a thesis altogether more than they were able to accomplish; and the results have been farcical. In North Germany the usual thesis is a design, which the senior student is qualified to attempt. A test may be done instead, but generally is taken only by students who wish to specialize in technical physics; and this test is not expected to be a research, though it may become so in the hands of a real genius. Further, the thesis, or "diploma-task," as it is called, is expected to be done after the completion of all the rest of the course, and from six weeks to three months are allowed for its performance, during which it is expected that the student will do no other school work. The German diploma-task therefore amounts to an outright addition to the course, both in time and work. I doubt if any American

engineering faculty would be able to keep its graduates hanging on for a semester to do a thesis, after their classmates in the other colleges had gone; and, under the circumstances, I think that we are wise to do away with the undergraduate thesis altogether and to require our students to put the time formerly wasted on it to some use on the regular courses. In this connection it is interesting to note that Munich does not have the diploma task and never has had it. The reason for this is that the task is of no value, unless it really is done by the candidate without the aid of other persons; while to set a young man at a difficult task, upon which depend such serious consequences for himself, and on which he necessarily works without supervision, and to require him to do it without improper aid, is to expose him to too severe temptation.

In spite of the advantages under which they work, the German technical universities do not succeed in sending out graduates who are at once practical men. Employers make the same criticism of their young graduates that they do of ours, that their heads are full of theoretical knowledge, but that they are unable to take hold of a job and accomplish results. It is doubtless necessary for us to realize our limitations, and I hope that our brother engineers in practice will appreciate them also. A little consideration will show that, for a man to be practical, that is, for him to be able to produce results, he must have an intimate knowledge of the details of his situation. Otherwise neglect to consider some detail may ruin the best general plan. To attain such minute knowledge requires experience of one's field. Also the knowledge that one uses must be so familiar that it comes at once when wanted. To attain this familiarity requires practice in the use of one's knowledge. Now both experience and practice require time, hence the young graduate must be on the job for a while before he can acquire them. If the engineering school could train its students for a narrow enough specialty, they might be graduated as practical men in that limited field; but, for reasons stated above, it is not for the best interests of our students that we should do this, though

I have pointed out means by which I hope that we can work toward this end. If, under our present conditions, we turn out graduates who are sufficiently equipped with professional knowledge, sufficiently practiced in the use of it, and sufficiently adaptable, so that they are able within a reasonable time to acquire the experience and practice which they lack initially, and to become of real commercial value, we are doing all that can be expected of us.

President Schurman of Cornell University some years ago, with reference to the work of Sibley College, used the words, "Theory without practice is empty." Our friends in practice have been mindful of this fact, and their criticisms have produced an unfortunate effect upon our students. As far as my own observation goes, the latter are eager for practical information and impatient of instruction in theory. For example, they would be more interested in copying a set of proportional units for the design of a machine part, than in studying themselves into a real understanding of the Carnot cycle. They would probably never have occasion to use the empirical units; and, if they did, they would very possibly find them unsuitable to their particular case; while the Carnot cycle more or less lies at the foundation of everything that they ever do in engine work. While it is true that "Theory without practice is empty," it is equally true, as President Schurman indeed coupled with it, that "Practice without theory is blind." I feel that we teachers of engineering must stand against the present tendency among our students, and, like our German colleagues, insist upon broad and thorough instruction in fundamental theory, as one of the essential bases of an engineering education.

The German technical universities give not only the first degree, but also that of "doctor-engineer." The doctor's degree is conferred upon the holder of the first degree of any German technical university who presents an official certificate of good character and "A scientific dissertation in the German language, which shows the ability of the candidate as an independent technical scientific worker."* The disser-

* Wie wird Man Maschinen Ingenieure.

tation is not necessarily a research, but commonly it is so. To prepare an acceptable dissertation commonly takes from one to two years. This is in contrast with the diploma task, and properly so, since a candidate for the doctor's degree should be of sufficient professional maturity to do good research work, and he is allowed time enough to do it. The work for the advanced degree thus consists in the development of the candidate's individual powers, by his measuring them against the difficulties of a highly specialized problem, which he has to solve on his own resources of skill and intelligence. On this point I cannot do better than to quote the words of Professor D. C. Jackson, "The (graduate) student should be thrown largely on his own responsibility (in the study of a few subjects only) and should not be harassed in getting up the details of numerous minor subjects. . . . Very few of the (American) engineering schools possess concurrently all of the requisites for successful graduate instruction, namely, a teaching force sufficiently strong in numbers and in experience, and adequate space and laboratory facilities."

The engineer who wishes to do graduate work can probably succeed better in Germany than in most technical colleges in this country, because the German system is excellently adapted to the needs of the graduate students. The reasons are that, (1) the ample equipment of the German institutions in laboratories, museums, collections of models, and libraries, is all necessary for successful graduate work; (2) the German institutions are better provided with funds for graduate work than are any but a few American colleges; and (3) the graduate student is more likely to be able to work under a professor of high rank in the engineering profession in Germany than in the United States.

(*To be concluded*)

The second part of Dean Shepard's paper, treating of the faculties of German technical universities will be printed in a later issue.

Written discussion on the above paper, if received before Dec. 1, will, with the approval of the Editing Committee, be printed in the PROCEEDINGS. Contributions should be brief and interesting and should add something to the subject.—ED.